WORKING PLACER DEPOSITS

IN THE

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BY

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ALTHOUGH it is less than forty years since gold was discovered in California, it is already very difficult to ascertain what the truth of the history is. This is owing to the fact that long before the real discovery, gold which was found in Mexico, was credited to California, because it was brought to the East by vessels which reported it as coming from there. It is also owing in part to the fact that but little was known of the country, and that travellers who wrote about it, in the desire to feed the appetite for the marvellous, reported what they imagined rather than what they found, as coming from them. Others, from selfish or mercenary motives, reported what they hoped would bring emigration or raise the value of the lands they owned, so that little or no credit should be given to what was written previous to about the close of the last century. There does not seem to be any truth in the statement that Sir Francis Drake found gold in California (New Albion) in 1579. That found by Captain Jediah S. Smith during his overland journey in 1826 was found in the Sierra Nevada Mountains, and not in California. One of the first authentic records of finding gold was near the Colorado River, in San Diego County, in 1775. But little work was, however, done at this place, as the ground was too poor to justify any serious exploitation of it.* The true history of the subject appears to be that towards the close of the year 1833†, or the beginning of 1834, J. P. L. Leese came to Los Angeles from Taos, New Mexico, bringing grain gold which had been washed out of the

* Report of the State Mineralogist of California, 1884, p. 217.

† Eng. and Min. Jour., vol. xxxii., p. 170.

placers there. About the same time, a Spaniard named Palacios came to the same place from Guaymas, in the State of Sonora, bringing with him silver bullion in bars and bricks, and gold in grains from Sonora. Both lots together amounted to about ten thousand dollars in value, and were for the most part taken out of the country, being carried by trading ships to Boston. A part of it was worked up by the jewelers in Los Angeles, but no tradition or belief that any part of California contained gold in workable quantities can be authenticated up to about 1841. In the early part of that year, Don Andres Castillero, a Mexican gentleman of scientific education, went to Los Angeles and Santa Barbara, and saw what he believed to be evidences of the occurrence of gold near the rancho of Las Virgines, and brought with him specimens to Santa Barbara, which he said indicated placer gold. In the month of June, 1841, Francisco Lopez, who had met Castillero in Santa Barbara, while riding over the ranch of San Francisquito, about thirty-five miles north of Los Angeles, found gold in a field of wild onions, which he took back with him when he returned to Santa Barbara. The rumor soon spread, and although very few of the Californians had any practical knowledge of gold-washing processes, there were a number of natives of Sonora, and other parts of Mexico and California, especially in the central part of it, who had seen placers worked, and during the first two rainy seasons following, a few hundred adventurers, from San Diego to San Luis Obispo, flocked into that part of the country and were profitably engaged in winnowing and washing gold, which was sold at Los Angeles every year. During the first year Lopez is said to have taken out about $8000. The value of 18 ounces sent in November, 1842, to the U. S. Mint at Philadelphia, was said to be about $340.

It is an undoubted fact that the Jesuit missionaries for many years previous to any reported discovery of it, had known that there was gold in the country, and placer deposits had even been worked in a small way at their station of San Fernando in Los Angeles County, but it was discouraged by the priests, who, believing that the passion for gold was demoralizing to their people, taught them that the working for, and the possession of gold, was detrimental to their own interests, and contrary to the true principles of religion. The simple folk accepted the dictum, and but for the

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rumors which came to the East so repeatedly, and from such different sources that they could not be treated as myths, the gold might not have been discovered for many years.

A carpenter, named James W. Marshall, who had been attracted to California, and was working as a millwright putting up a saw-mill on what is now known as Sutter's mill, at Coloma, El Dorado Co., on January 19th, 1848,* made the discovery of gold in the sluice of the mill which he was building, and subsequently in other places. On the morning of this day, Marshall went out to superintend the men, and after closing the forebay gate, shutting off the water, walked down the tail-race to study the character of the sand and gravel which had been removed during the previous night, for he had conceived the idea that there were minerals in the hills, and he said so to Sutter, who had only laughed at him. As he was examining the débris, his eye caught the yellow metal lodged in a crevice on a natural riffle in soft granite, some six inches under the water. After a close examination, he suspected that this substance was gold. Being a shrewd man, who realized the importance of his discovery, he went on with his work as usual, showing the nugget to his men, however, and making some conjectures about the extent of the gold-fields, watching carefully for any further developments, and in the course of a few days had collected a number of ounces of the metal. About four days after the discovery, he had occasion to go to Sutter's Fort, now Sacramento; so taking the grains with him, he examined the rest of the country, and again discovered the same metal in a ravine in the foot-hills, and at a place known as Mormon Island. Sleeping under an oak tree, some ten miles from the fort, he reached there the next morning, and soon put an end to all doubt as to the value of the discovery that he had made. It has been claimed that the gold was shown to Marshall by Peter L. Weimer, one of his men. Both men appear to have been together when the nugget was found, but Marshall, having a horse, went to tell Sutter of his discovery. No one of the three, however, knew that what had been found was gold until it had been assayed at San Francisco.

These discoveries were soon noised abroad, and caused the abandonment of the poor placers of the southern part of the country,

* Min. Resources U. S., 1872, p. 111.

and the influx of a host which depopulated whole villages and towns, the city of San Francisco amongst them, and caused the wildest excitement all over the East.

Although the discovery was so memorable, and the results of it were so important, it is hardly possible to-day to distinguish the spot where it was made. It has been proposed many times that a monument should be erected at Coloma, on the site of Sutter's mill, but it has never yet been done, and it is not now likely that the spot can be distinguished with sufficient certainty to make it worth while to attempt to mark it, so that it is not probable that any monument will be erected.

Marshall died in Kelsey, California, on August 12th, 1885, in great poverty and distress. His cattle were killed and his claims jumped by men who hunted him during the last years of his life in the hope of discovering the secret of finding gold, which they believed him to possess. His life was made wretched by his disappointment in never finding the fortune he was seeking, and which he always supposed to be almost within his grasp, but which he never succeeded in obtaining. Some years before his death, the Legislature of California appropriated $200 a month as a pension for him for two years. At the end of this time the appropriation was not renewed, and the man who had been the means of the finding of one billion, six hundred million dollars' worth of treasure in that State, died a wretched pauper.

PLACER DEPOSITS.

When gold is found in sand or gravel, the deposits are called placers. These are formed by the accumulations of the débris washed down by ancient rivers, often forming deposits of considerable depth and variable richness, which have themselves sometimes been again torn up and redistributed by more modern streams, forming deposits of comparatively recent origin. We have thus the ancient and the modern placer. They have, also, sometimes been either wholly formed, or, in some cases, only partially, by the precipitation, of the gold dissolved in the waters of filtration, by organic matter.* According to the depth at which the gold is found, they are called shallow or deep placers. The shal-

* Trans. Am. Inst. Mining Eng., vol. ix., p. 643.

low placers are those deposits which extend to the depth of about ten feet or less from the surface. It was in these deposits that the gold was originally found in California, and as they are usually very rich, they are the most eagerly looked for in the early settlement of a country. They exist, scattered over a great extent of territory, and were so rich and so largely worked that in the first five years after their discovery, they produced, notwithstanding the wasteful and primitive methods which were used to work them, $180,000,000. They are not always of the same richness and value, nor are they always capable of being worked. Abundance of water is the chief requisite to their successful treatment, and even then they are often worked on a wrong theory, and only while the pay-dirt continues very rich, and by the rudest and most wasteful methods, much more being lost than was ever extracted. They were often abandoned as worked out before their real richness was discovered, some of them having been thus worked over two or three times in succession. Even now the Chinese make a good living by working over these old tails. Up to the time of the invention of hydraulic mining, the shallow placers furnished nearly the whole of the gold produced in California. They were abandoned, because with the primitive means in use at that day, they were no longer profitable, but they are by no means exhausted. It is not improbable that it will, in the near future, be found profitable to work them over again on a large scale, both because the gold was only partially extracted as well as because the gold has concentrated in them from precipitation of the minute quantities of gold contained in the waters of infiltration.

It is estimated* that since 1851 the total amount of gold produced in the world has been $4,500,000,000. Of this sum, California has produced about $1,125,000,000, and of this amount, $1,000,000,000 have been produced by the working of the auriferous gravels.

Not unfrequently small particles of the precious metal were found in the roots of the grass or of small shrubs torn up by accident or design. Sometimes the shining particles of gold were seen in the streams whose course lay through the ancient deposits or received the drainage waters from them. It was not till long after these

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* Prod. Gold and Silver in U. S., 1881, p. 616.

modes of occurrence of gold had become known that it was discovered that the precious metal might be found deep down in the earth on the bedrock of ancient rivers which had been covered with detritus to the depth of hundreds of feet. These modes of occurrence give rise to many methods of exploitation of gold, the principal of which are known as placer and vein mining. The placers are divided into shallow and deep placers, and the method of mining varies, according to the manner in which the gold occurs in each, as follows:

In Shallow Placers.

Gravel mining.
Sluice mining.
Beach mining.
River or bar mining.

Deep Placers.

Hydraulic mining, { Surface mining. / Drift mining.

Vein Mining.

Amalgamation, { Dry crushing. / Wet crushing.
Concentration and chlorination.

Gravel Mining.

While the shallow placers are near the surface, the deep placers, as the name implies, have sometimes their richest portions near the bedrock, which is often two to three hundred feet below the surface, where the ground is generally quite poor. The formation of both these deposits is owing to the same general causes. In many cases the shallow placers are formed by the destruction of pre-existing veins, and the accumulation of the gold from the detritus by the action of the waters. In others they have undoubtedly been formed by the infiltration of small quantities of gold in solution in water which has percolated* through them from the surface, and has been thrown down in the sand by or-

* Trans. Am. Inst. Min. Eng., vol. ix., p. 644.

ganic matter, either dissolved in the water or scattered as solid particles through the sand.

The methods by which shallow placers are worked differ from each other more by reason of the differences in the occurrence of the gold than because of any difference in the principle of the methods employed to extract it. The shallow placers are frequently divided into wet and dry diggings, wet being those which are found in the bars and beds of streams, dry being those which are found in the gulleys and the bottoms of the streams which are large in some seasons of the year, and dry up at others, so that water can only be had during certain portions of the year. These last claims, where the water is transient, are sometimes called "gulch claims." They are also sometimes called "dry diggings," and are not unfrequently very rich in gold. All these were worked in the early days, but as they have ceased to be very profitable, they are now left to the attention of Chinamen.

In the very early days the pan was almost the only instrument used. It still holds its place as a prospecting tool, although it has lost its importance as a working instrument. At first, it was any household pan that could be made available. Now it is made of Russia sheet-iron, but as its shape is such as is convenient for household purposes, the same pan is used for one and the other. Upon its skilful manipulation the success of the miners depended, and they soon learned to use it so that in the rich deposits or even in the poorer ones, they handled it with almost artistic skill. The work performed by it was small in amount, but so certain in its results, that its revelations were regarded as infallible, and districts were overrun or abandoned according to the results which it gave. In studying the method of its use, the work may be divided into periods, which will generally be found to correspond to five different phases or sets of motions: *First.* The pan is filled with the pay-dirt to about two-thirds of its capacity; it is then, according as water is abundant or scarce, placed in the bottom of a shallow stream, or set in a hole filled with water. It is usually placed on the bottom so that the operator can use both his hands. Occasionally it is held in one hand while the work is done with the other. The whole contents are thoroughly stirred with one or both hands. Any lumps that may be found are broken and mashed between the fingers, so as to mix them all thoroughly with the water. When the

whole contents of the pan are in the condition of a thin homogeneous mud, the first part of the operation is finished. *Second.* The pan is now taken in both hands, a little behind its diameter, raised nearly to the level of the surface of the water, but a little below it, inclined away from the operator, so that a very slight movement disengages all the light matter and causes it to pass over the edge of the pan. This is continued until the water which passes off is perfectly clear. There will remain in the pan, after all the lumps of clay have been broken up, only pebbles, gravel, heavy sand, usually black, and gold-dust. The *third* stage commences with raising the pan above the water and picking out all the large pieces, examining them before they are thrown away to see that they do not contain gold. The pan contains but little water, so that it is quite easy to get rid of the large pieces of sterile matter, either picking them out or pushing them over the edge. There will be now in the pan little else than small-sized pebbles, the black sand, and the gold. The *fourth* stage is to incline the pan a little under the water, causing the next smaller-sized pieces to pass in such a thin stream over the edge of the pan that every particle is visible, so as to be sure that no gold goes over. The *fifth* stage consists in lifting the pan out of the water with a little water in it, and by a dexterous movement of the wrist, causing the sand to pass with the water across the bottom of the pan, leaving "the color" on the opposite side. The pan is then inclined to the side where the sand is, and this is washed out with small quantities of water taken up in the hollow of the hand and poured on it, causing it to pass out, leaving the gold behind. The black sand, however, still remains with the gold. There are three ways of getting rid of it. The first is with a magnet when the sand is magnetic; the second, by dexterously blowing away the sand after it has become dry, and the third by the use of mercury. The first two are the methods most generally used.

The ordinary miner's pan has a flat bottom; the Mexican and Brazilian modification of it is a round piece of wood or metal, which is conical, and not over three inches deep in the center, and is called a *batea*. It requires skilful manipulation. On the principle of this implement some successful prospecting and working tools have been made.

Great use was made in the early days of the *horn spoon*, which

was cut out of a large ox-horn so as to make a sort of spoon about a foot long by two to three inches wide. Horns of dark color, or those which were black at one end at least, were much sought after for this purpose, as the gold is so much more readily seen on a dark than on a light surface.

All of these were rather prospecting tools than mining implements. They were, and still are, used in all new fields, both as prospecting and working tools while the pay-dirt is rich, but when it becomes poor, so that the quantity to be treated in a given time must be great, they are no longer capable of treating the large amount necessary to give a fair return for the labor, so that if water was not abundant, the field was abandoned, or if it was, "machines" were substituted for the pan. The first of these used was the "cradle," or "rocker," as it is often called. This was a box on rockers, having a grating on the top 20 inches square, called the riddle, on which the gravel was placed. Water was poured on this, which carried the pay-dirt through. It fell on an inclined blanket-apron, which carried it to the back of the lower part. On the lower part are two riffle-bars, about one inch high. The cradle is slightly inclined to the front, so that all the dirt and water put in at the top ran down the apron to the back, over the bottom, and out at the front. The weight of the water used in the cradle is from three to four times the weight of the dirt to be treated, so that the work must be done near the water. The very fine gold is caught on the blanket-apron, the coarser particles behind the riffles; the larger stones are easily picked out from the riddle, and the small ones are left to help break up the tough dirt. The motion of the cradle must be constant to dissolve the dirt and keep it loose; otherwise it would pack hard and the gold would run over it. The amount of water used must be large, or the excess of dirt would not be carried off. When the blanket is to be cleaned up the riddle is removed and the blanket taken out and washed in a pail. All that is caught has to be panned. If the rocker is to be worked by one man, the water is collected in a hole made at his right hand. With the left he moves the rocker, and with the right he pours water over the dirt. If the "pay" is near the water it is brought in pails or wheelbarrows. If this cannot be done, it is "packed" on mules or brought in wagons. If worked by two men, one brings the water and the other rocks. If the water can be brought by a sluice two men can work rapidly. One

man can treat one and a half cubic yards in a day; two men can do nearly three times as much. When the gold is fine, the cradle, though very cheap, is not economical, as most of this gold is lost. When it is coarse and the supply of water uncertain, it is a very useful machine; but its output is very small, and the amount of labor required to be done with it is very large. At the best it can only treat half the amount that can be washed in a tom, with the same amount of labor. Its use has been abandoned in this country, except by the Chinese.

The rocker was replaced by the "tom," which was really only two launders or sluices, and required a supply of water from another sluice. The apparatus consists of an upper sluice-box about 14 feet long, 20 inches wide at the upper end and 30 inches at the lower, with an incline of a little less than one inch to the foot. The lower end of the launder is cut off at an angle of 45°. This is closed by a grating of punched sheet-iron, which allows everything but large stones to pass. This ends over a riffle-box, about 3 feet wide, and 11 to 12 feet long at the same incline, with five or more riffles, into which mercury is put. One man throws in the dirt, another stirs it, breaks up the lumps of clay and dirt, and removes the large stones. The gold is caught in the riffles, which are sometimes supplemented with blankets. It is worked by from two to four men. Two men will do five times as much with the tom as with the rocker. It is never worth while to use the tom except when the gold is in coarse grains and the quantity of pay dirt small. It is now only used by the Chinese, who use it to work over the "exhausted" tails of the abandoned workings of the early miners, and are quite satisfied if they only make seventy-five cents, or even less, a day.

Sluice Mining.

Almost all the shallow placer deposits are now worked by sluices. These sluices are tools of great value and simplicity, and their invention and use has probably done as much to increase the wealth of California as any other one thing. They were for many years the most important instruments used in working the placers. The sluice was invented in California, although it has been used elsewhere under, however, very different conditions. It has been brought to its greatest simplicity, as well as its greatest perfection in this country. It is made of rough unplaned boards, and is

of almost any length over 50 feet, and is not less than 8 inches wide and 9 inches deep. The width is usually 16 to 18 inches; it may be thousands of feet in length. The boards are an inch and a half thick and 12 feet long, just exactly as they come from the mill. The sluice is made in sections. Each section is called a box, and as the boards are from 12 to 14 feet long, the sluice is said to be made up of so many boxes, which indicates the length perfectly. The sides of these boxes are from 18 inches to 2 feet high. The bottom boards are sawed for this special purpose, and are 4 inches wider at the lower than at the upper end. The narrow end is intended to fit into the wide one of the upper end of the next one below. The sides are nailed upon the bottom. No attempt is made to make them tight, as the joints become filled with sand or swell tight after a little use. The sluices thus made rest upon trestles with a descent varying from 8 to 18 inches in a box. This descent is called its grade, and if the fall from one end of the box to the other be 8 inches, it is said to have an 8-inch grade. It is generally not desirable to have a grade of less than 8 or more than 20 inches. The boxes are put up on trestles with great ease and taken down as easily, and are transported from one claim to another after the placer has been worked out. The amount of water to be used in a sluice will depend on a great variety of circumstances, especially the quality and quantity of pay dirt to be treated in a given time. To work successfully there should be plenty of water. In general the depth of water on the bottom of the sluice should not be less than two inches.

The grade depends upon the character of the "pay," as the dirt containing the gold is called, the length of the sluice, and the character of the ground, and the quantity of water available. The steeper the grade the more rapidly the dirt will be worked, but the greater likelihood there will be of loss in gold. Ordinary dirt will be entirely broken up within from 200 to 250 feet of the point where it is charged, and from here on, the sluice has but one function, namely, to catch the gold. The point being determined at which a given quality of dirt will be completely broken up, the grade beyond that point is usually lowered, but must always be sufficient to carry off the excess of material. It is rare that a sluice is made long enough to catch more than 50 per cent. of the gold contained in the sand. Tough, clayey material requires a steeper grade than any other. To break up this tough clay the flow must be rapid,

but in such a case the sluice must be long. The grade must always be less in a short sluice than in a long one. This is owing to the fact that there is always danger that a rapid current over a short distance will carry off the gold, whereas in a longer distance it would probably be caught. When the amount to be treated is large, the grade should be high, the water abundant, as also when the ground contains a considerable quantity of large boulders. It is unusual for the sluice to have the same grade throughout. It is generally made steep at first, so as to break up any tough material, and less steep afterward. Usually, however, the miner makes the grade conform to the lay of the ground, whatever that may be, and regulates the height of the trestle by the ease with which he can throw the dirt into the sluice. There is always danger, when the dirt contains any plastic clay, unless the grade is very high, that this will roll over and over on the bottom, and take up the gold which has already been deposited and carry it out into the tails at the end of the sluice. Such balls may sometimes roll a thousand feet without breaking. For this reason special care is taken to make the sluice for this kind of work very steep at first to break up the clay, and lower afterwards to catch the gold, or, better still, no attempt is made to work the clay in the sluice; but it is first puddled either by hand or machine, and not introduced into the sluice until it is in the condition of liquid mud. For this reason when clay balls are found in the sluice they should at once be removed, broken up, and puddled. When there is but little clay hard work is all that is necessary to break up the clay in the sluice, but when there is much of it it is cheaper to puddle the whole than to run the risk of losing large quantities of gold. When there is a great deal of gravel or large stone to be removed, under currents are used. For this purpose the end box is left open, the bottom for the width of the sluice is covered with a grating sufficiently coarse to allow all the fine stuff to pass through. Under this a short sluice at right angles to the direction of the main sluice is placed, which ends over another sluice parallel to the main one but at a lower grade. The material coming from above, which is fine enough, passes the grating and goes on in the other sluice. The stones and coarse stuff fall out at the open end by the force of their own velocity.

The gold is caught in the lower end of the sluice by various devices, which consist of the insertion of some kind of false

bottom. Even though the boards are rough, with their splinters turned up stream, they would soon be worn smooth by the material passing over them, and the gold be swept away in the current. In order to prevent both the mercury and the material from running out of the box too quickly, narrow strips of board are fixed on the bottom. These may be either transverse or longitudinal, or both. These strips are called "riffles." Sometimes, where the works are to last for a considerable time, the sides of the sluice are protected with a "lining," so that they will not be too rapidly worn. The longitudinal riffles are from 2 to 4 inches thick, 3 to 7 inches wide and 6 feet long. From two to four are placed on the bottom of the box. Each box will, therefore, contain two such riffle bars, and whatever the sluice contains, whether two or more, is called a set. They are wedged to their places, and held together by a certain number of transverse riffles, so that they may be easily removed for a clean-up. It would not do to put them in permanently with nails, as they must be often taken out. Immediately after a clean-up the riffles are adjusted in the boxes. There will thus be in each box, with longitudinal riffles, sections which will be 6 feet long, and the length and depth between the riffle bars. When the sand is fine, transverse riffles are often used alone, but when there is a small amount of pasty material to be broken up, zig-zag riffles at an angle of 45° are sometimes used. These riffles reach nearly across the sluice and are nailed to the bottom. The water, with the fine metal, passes over them, while the coarse gold and the clay go from side to side with considerable velocity. Such riffles do not catch the gold, but only help to break up the clay. They are placed in the upper part of the sluice, which must always be terminated by the ordinary riffles. Occasionally the sluice has a wooden pavement, made of blocks cut across the grain of the wood and set several inches apart, but so that they can be easily removed. They are not so permanent as a rock pavement, and are not much used except in hydraulic mining.

The coarse gold is easily caught at the head of the sluice, but much of the fine gold would be lost if nothing farther was done to catch it. For this purpose mercury is put into the head of the sluice, being poured through a strainer to divide it into small streams or in some other way broken up into small globules. It is usually not added until from one to two hours after the commencement of the working. It is caught in the riffles and amal-

gamates the fine gold. Sometimes the pores of the riffles bars are impregnated with mercury by introducing a gas pipe at one end, and filling it with mercury to a considerable height. This is very troublesome and scarcely pays for the work it occasions, as the riffles must be cleaned by scraping the amalgam formed from the wood. It gives as much trouble as copper plates, and is much less effective. Copper plates are not often used in placer working. These are extensively used in battery sluicing. When they are used they are amalgamated by cleaning them first with dilute nitric acid, which removes the dirt, and then rubbing them with mercuric nitrate or with mercury alone, which is rubbed on with a piece of cloth. When the former is used the nitric acid brightens the plates, and the mercury at once amalgamates with the copper; the green slime of basic copper nitrate thus formed must be carefully rubbed off. It is much quicker to clean the copper with potassium cyanide, but this requires more care, as if too strong a solution is used, or the plates are left in it for too long a time, they become black and will not amalgamate. When plates are used the current must be slow and the water shallow. A swift current carries off the fine gold and deep water does not give the gold time to settle. When a speck of gold settles on any part of the plate others will collect around it. The more gold there is on the plate the better it catches the gold, so that when the miners can afford it they amalgamate the plates with gold; when they cannot afford that, with silver, and where that cannot be done with mercury alone. The amalgam is left to accumulate until it is from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch thick, but not thicker, as there is danger of its being stolen. It is then in a hard mass, which must be separated by force. To do this the plate is heated until it is a little hotter than the hand can bear, and the amalgam separated by scraping or with a chisel. A copper plate $\frac{1}{10}$th of an inch thick, after it is once amalgamated, can be made to last from five to ten years if treated with care. An amalgamated copper plate is better than a bed of mercury of the same size, but it must be kept clean by rubbing. This is usually done with an india-rubber tool, not unlike the one so widely used for cleaning windows. The time between two clean-ups is called a "run," which usually lasts from six to ten days. The sluice is generally run only in the day, but is sometimes worked day and night. Men must be kept on the watch to see that the material coming down does not choke the

sluice so as to make the water pour over the sides. Whenever a dam commences to form they break it up with an iron bar and throw out the stones with a fork.

Sometimes the sluices are made double by running a partition through the centre of a large one. This is done either when two companies are working on the same ground, in order to avoid the extra cost of two separate sluices, or when, because of the variable supply of water, it is desirable to run double the amount while the water lasts.

Sometimes, in order to prevent unlawful clean-ups at night, the sluices are paved with stone. These paved sluices, however, are not usual except in hydraulic mining. An active man can pave in a day eight hundred square feet of such sluice, made of cobble stone six to eight inches in size. They are laid in loose, but after the sand has run over them from half to three-quarters of an hour they will be packed quite tight. They are difficult to lay and to clean up, but are much more permanent than the wooden pavements. A patrol with a shot-gun loaded with bird shot, and a plentiful supply of salt and pepper in the charge, is a much better protection against theft. No one who has ever heard of the pain caused by the reception of such a charge would ever attempt to clean up for his neighbor.

The gold, quicksilver, and amalgam are caught in the spaces between the riffles. All the mercury is introduced into the top of the box and passes down with the rest of the material. The water should be at least two inches deep over the bottom. Boulders and stones must not be allowed to remain in the sluices, as they not only grind up the mercury and amalgam into flour, but are in danger of becoming wedged and obstructing the free flow of the water. They are taken out along the sluice whenever they are observed by the man whose duty it is to watch for them.

Sometimes a sluice is made without any boards by making a channel in the earth into which a stream is run. This channel is either in the pay dirt itself or in barren ground, the uneven bottom of which makes catch places for the gold. When a clean-up is to be made the water is turned off, and what is collected on the bottom panned. Only the coarse gold is saved; the fine is entirely lost. As it uses more water for the same amount of ground treated, it is only used in temporary workings. Such sluices are called "ground sluices."

When the rich dirt is below the level of drainage it is washed in a pit. There are two ways of doing this, depending for their application on the lay of the ground. One is to pump the water used in washing out of the pit with a Chinese pump, and the other to make a covered tail race through which the water can flow to a lower level, and cover it as the work progresses with the washed ground. This generally necessitates the use of a short sluice, or even only of a "tom." An active man can throw from three to seven cubic yards of dirt a day into the sluice, provided he does not have to lift it more than four and a half to five feet; at a less height he can do a little more. The quantity depends also somewhat on the character of the dirt which has to be moved. Sand without clay or boulders is most easily washed. Six cubic yards daily per man is fair average work. In a ground sluice where there is no lifting, but only shoving to be done, the average work per man will be about twenty-five cubic yards per day. When the sluice is worn out it is burned and the ashes treated for gold. If it has been used for some time the amount of gold recovered in this way will sometimes be sufficient to purchase a new sluice.

To make a clean-up the dirt is no longer put in at the head of the sluice. When the water runs entirely clear, five or six sets of riffles are taken up at the head of the sluice, their contents washed down to the riffles below. The sand is washed over, while the gold and amalgam lodge at the riffles and are removed. The next sets are then removed, and so on; sometimes twenty or thirty sets of riffles are taken out at a time. The work of a clean-up will generally take half a day to a day. It should not be made frequently, as it consumes so much time. It is generally done on Sunday. The length of the run will depend on the richness and character of the dirt. The amalgam collected is strained through a cloth and retorted.

When the dirt is rich and water cannot be had, the process of "winnowing" is used. For this purpose all the stones are picked out and the dirt is made as fine as possible. It is then tossed by two men on a hide or a blanket, with the object of having the fine particles carried off by the wind. After this has concentrated the pay dirt somewhat, it is again tossed on a "*batea*." Where the pay is below the surface, small shafts are sunk and galleries run short distances in all directions from it. The material brought to the surface is "winnowed." This is called

"coyoting," from its resemblance to the burrows of the coyote. None but the richest pay can bear this kind of work. Winnowing machines are now being made for use. The loss is enormous, but where they are used what is obtained is all gain, for without this method nothing would be had.

In very many of the deposits, after the loose sand has been worked, there remains below it a hard mass which was recognized as containing gold, but which could not be extracted. At first this was sent to the stamp-mill, but as all of it did not contain gold, and all the coarse boulders which were sterile had to be crushed so as to pass through the screens, as well as the fine material which contained the precious metal, this method was abandoned. Most of this hard material, which is called "cement," disintegrates when it is exposed to the air for a certain length of time, or is broken up by the frost. The cementing material is usually iron oxide, or clay. It was then proposed to work it by the hydraulic method, interposing in the course of the sluices a large number of "drops" and "grizzlies" and "undercurrents," in order first to break the cement by concussion, then to separate the larger sized boulders and catch the gold in the finer material.

When the deposits are very large such a method may be possible; generally, as it costs too much in time and labor, it will not be profitable. Disintegration by exposure and then washing in large revolving iron pans seems to be the most profitable method that has as yet been used. The pan bottom is perforated, and is so arranged that after a certain amount of the cement has been treated and all the fines extracted by water and passed into the sluice, a door in the bottom of the pan may be opened to let out the material too large to pass through the perforations into the sluices, so that it may be thrown out into the tails, which collect on the ground below. In the pan four arms with plowshare adjustments revolve to break up the cement, and make it fine enough to be carried through the bottom into the sluices. When the cement has been weathered or frozen and thawed, this work can be rapidly done. A pan 5 feet in diameter and 2 feet deep can treat from 40 to 120 tons of such cement per day, depending on the hardness of the gravel and the power available to move the pan.

Beach Mining.

It has been known from the very earliest times that gold occurred in river sands, and it is there that it is chiefly looked for in the early exploring expeditions in any country. That it existed to any extent in the sands of the sea beaches does not appear to have been known, or that sea water even contained a very minute portion dissolved in it, was not discovered until within a few years. The discovery of gold on the sea beaches of California and Oregon seems to have been like most of the other gold discoveries, the result of an accident.* A party of miners prospecting in northern California in 1850, of whom Eugene de Bertram was one, were forced by the jungle of the main-land to follow the line of the beach. In passing along the shore at what is now called Gold Bluff, in Klamath County, they found it dazzling yellow in the sunlight and covered with gold, which the natural action of the waves had separated from the beach sands, and so concentrated it that it yielded nearly fifty per cent. of precious metal. Collecting some of the sand they went first to Trinidad, about thirty miles distant, and from there to San Francisco, where a company was formed to mine the beach and collect the gold. Excited by the richness of the sample, and the truthful though somewhat exaggerated story of the miners, an expedition to Gold Bluff was formed, and started from San Francisco in a revenue cutter. In order to keep the secret from the people of Trinidad, they anchored off Gold Bluff, and endeavored to land on the spot where the gold had been found. The first boat contained six persons, but on nearing the shore it was swamped and all were drowned but de Bertram, who was rescued by the adroitness of a friendly Indian, who happened to be on the shore at the time. The rest of the party returned to Trinidad, and went on foot to the beach. But there was no gold there, and no trace of it could be found. Discouraged and disheartened, most of the party went back to San Francisco, but de Bertram, though weary and almost hopeless, yet believing that what he had once seen he could find again, waited and watched until a favorable wind and tide washed the gold up again. The result of this discovery was that soon the beaches were explored, and have since that time been worked with moderate profit to the owners; not sufficient, however to cause any very great excitement or the investment of any

* Min. Com. Report, 1870, p. 87.

very large amount of capital. As the concentration is done without cost, and the troublesome question of tails does not have to be taken into consideration, since the sea takes care of them, it promised to last into the distant future, and to give a rich return for the labor and capital expended. The excitement caused by their first discovery soon received a damper, for with the rude and careless methods by which they were worked, not more than one-fifth of the gold was separated, and the uncertainty of the winds and the waves bringing any up for a considerable length of time, for it was necessary that the wind should come from a certain direction, to cause the light particles of gold to be brought up on the beach, soon proved that no great fortunes were to be made here. These beaches were apparently soon exhausted and for a number of years were abandoned, on the supposition that they were no longer worth working. Many persons, supposing that these golden sands came entirely from the deep sea, undertook to dredge and to work the sands with complicated and expensive machinery, which, however, soon proved to be an entire failure.

These beach-sands occur in the northern counties of California and the southern counties of Oregon, extending from Cape Mendocino to the Straits of Fuca. They are also found in small quantities as far south as San Francisco, and as far north as Puget Sound, but in too small quantities to pay for working, the district where it pays to work, being confined to the above limits. The diggings extend along the coast for three or four hundred miles. The bluffs vary from 110 to 500 feet in height. They will average 200 feet. Most of them are vertical, but they are sometimes overhanging and have very narrow beaches at their foot. High up on the beach, where the action of the waves is very gentle, the sand is found in alternating layers of the fine material composing it, with the lighter material on the top. When, on a windy day, the light sand of the upper surface becomes dry, it is often blown away to such an extent as to leave the heavy black sand on the surface. Lower down, however, where the surf breaks, the sand is coarse, and in heavy weather may be composed almost exclusively of pebbles. In California, as in New Zealand and Australia, these gold sands sometimes extend considerable distances into the ocean. Opposite Crescent City, ten miles out to sea, gold was found in the soundings brought up by the lead, but all attempts to dredge it have failed. These sands have doubtless been deposited by some

ancient river flowing through the gold region of Oregon and California, which for ages carried in suspension, in its current, immense quantities of auriferous gravel, and which gradually filled its bed and the surrounding country with its deposits and subsequently became elevated to its present position above the surrounding country.

In some cases the whole length of the bluff is gold-bearing, with rich and poor streaks, yielding on the average 20 cents to the cubic yard, but the rich streaks giving as much as $135 to the ton, of gold .957 fine.* The sand contains gold and platinum in small quantities, in minute scales, most of which are flat, mixed with a very large percentage of black, magnetic, and ordinary quartz beach-sand. The shape of the grains, which can be seen when they are highly magnified, is oblong and doubly convex, with edges thicker than the middle, a form which would naturally result from the continued pounding of the grains. Their thickness is rarely more than 0.001 of a line. In length they vary from 0.3 to 0.7 line. Much of the black sand is composed of grains of nearly uniform size, but they are rounded, so that although the gravity of the sand is only one-fourth that of gold, the buoyancy of the latter counteracts this, and it is possible to separate them. The gold is not only buoyed up by the air, but is as easily moved by the water as the black sand itself, so that it requires the greatest skill to obtain "color" either with the shovel or the pan.

It was at first supposed that these beaches were confined exclusively to the coast-line, but it has since been discovered that older beaches containing the black sand exist as much as thirty miles back of the coast-line, and often at considerable elevations, and in such a position as to show that their elevation must have been very gradual. The black sand containing the gold, is sometimes covered to a depth of from three to sixty feet with sterile material. In Oregon these are called "back beaches;" they are worked either by stripping or tunneling.

All the early methods of extracting gold were based on the difference in specific gravity. The best of them did not save more than 20 per cent. of the gold. Plattner's process was tried, but was found to be too expensive to be used on a large scale, but the use of it for a short time confirmed the fact that fully 80 per cent.

* Prod. Gold and Silver in the U. S.: Burchard, 1884, p. 557.

of all the gold contained in the sands was being lost. When these sands contain gold that can be seen by the microscope, most of it is quite bright, though it is covered occasionally by a coating which prevents the contact of the mercury. In most cases this appears to be of an organic nature, and seems to have been produced subsequently to the formation of the bluff.

The remarkable purity of the gold obtained from the beaches has attracted a great deal of attention. This is undoubtedly owing to the fact that this gold being in an extremely finely divided state, and wet with the salt water for so long a time, has had the silver separated from it in the state of chloride, as is also the case with the other metals, leaving the gold almost pure. The value of these sands is very variable, depending on the situation and the state of the natural concentration at any particular time. Values of from $10 to $30 a ton are quite common, but the sand often has less, and sometimes contains many times this amount.

As the operation of mining is entirely dependent for success on the state of the weather, the direction of the wind, and the force of the tide, it is always uncertain, but as it requires very little outlay for plant, and not a great amount of labor, it is quite attractive; but as the concentration of the gold in sufficient quantities to work is dependent on the weather, the best claims are often unworkable for months, during which time the miner must wait patiently for any change of wind which will throw the sands up on the beach where he can reach them. He may not even be rewarded for many weeks for his patience in waiting by any days of favorable winds, or even by a single tide. The sea-water cannot be used without great loss for concentrating by hand, as it is too heavy, so that the beach miner must wait for nature to do the concentrating, which, when once effected and collected for treatment, may be entirely washed away in a very few minutes by a contrary wind or a heavy tide. Such uncertainties do not invite the investment of any large amount of capital.

A favorable wind, with the heavy swells at high tide, drives the sand upon the beach. The ebbing tide, as it recedes, washes out the fine particles of rock, the lighter materials retreating with the water, leaving the heavier ones, the iron, the gold, and the platinum, high up on the beach. When the tide is out, this sand can be scraped up and "packed" inland out of the reach of the waves, to be treated there. In the intervals between two tides, or when

sufficient has accumulated, the sands are washed in a sluice, terminated by a tom, with the ends and sides turned up. The bottom is perforated with holes, and underneath is the slightly inclined trough with silver-plated amalgamated copper plates. The sand, passing through the holes, strikes the plates; the heavy particles of gold are caught on the amalgamated plate and by the mercury, while the sands and the float-gold run off at the end of the sluice. The method is imperfect, all the more so as the iron-sand is more difficult to remove from the buoyant particles of the precious metal which characterize these sands, and which are very much lighter than those found in ordinary placer mining, chiefly on account of its state of very fine division. Much of it floats, and can be made to sink only by standing for a very long time, or by heating the sand, which is entirely impracticable in a large way. The probable quantity of gold is very uncertain, for a single storm will often wash out all the sand to the depth of 6 or 8 feet, leaving the rocks entirely bare.

It has been supposed by some that this gold is cast up from the depths of the sea, but this theory does not seem to be a probable one, for the reasons that the attempts to dredge it in deep water have not been successful, because all the bluffs which skirt these beaches contain gold, and because the black sand which covers the gold is also found in a number of places several miles inland, at a height very much above the present level of the sea. There are indications that the rivers have in former times been blocked by landslides, which have sufficed in some instances to turn them from their courses into other channels, and that the rivers themselves have carried down immense deposits into the sea, where the black sand, the gold, and the platinum in the more tranquil waters would tend to separate by gravity. There is also abundant evidence that the front of all the cliffs is gradually receding, and as they contain gold in sufficient quantity to be worth working, this sufficiently accounts for the presence of gold in these beaches. It is also constantly observed that after a very heavy storm which undermines the bluff, and causes large quantities of fresh material to fall, the sands are not only richer but the gold is coarser than before. Companies have several times been formed to work the bluffs, where they were rich enough to be worked. This would seem to be a very attractive enterprise, since the bank could be cheaply blasted and the sand hydraulicked, while the

sea would do all the concentration and would at the same time dispose of all the tails. It has found many enthusiastic adherents, but has, however, never been extensively tried, for the distance from which fresh water would have to be brought to wash the sand, sometimes 40 or 50 miles, makes the process impracticable. In many cases, especially in the interior of the country, the gold of the black sand, which is very fine, does not readily amalgamate until after it has been heated, which seems to destroy a film of organic matter with which it is coated, and which has consequently prevented the contact of the particles of gold with the mercury. It has been proposed to treat these sands with Plattner's process, but this has also been found to be generally impracticable, although the attempt to do so revealed the fact of the enormous losses that were being made by treating them by any other process.

It was very generally supposed that in the first mining the greater portion of the gold contained in the beach-sand was saved in the appliances that were used to collect them, and subsequently that the beach-sands themselves had become exhausted. But careful assays have since proved that by far the larger part of the gold was lost in all the earlier workings in the state of an impalpable powder, and in such small particles that it is scarcely visible with the microscope. How to separate these fine particles of gold from the heavy black sand has been a problem which if the sands had been richer would undoubtedly have been solved. The extreme lightness of the microscopic particles of gold, and the much greater weight and larger size of the grains of sand make it impossible to separate them by water or air, and in some cases the gold itself is coated with some substance which prevents the mercury attacking it. As there are millions of tons of sand that contain from five to ten dollars in gold to the ton, and are sometimes as high as $100, the experiments which were made to save it by chlorination and other chemical methods, confirmed the losses which were being made in the working of the sands, but suggested no practicable method of treatment.

One of the earliest worked and most famous of these localities is at Gold Bluffs in North California. The coast-line after leaving Klamath River is very broken and rocky. The sands appear at Gold Bluffs about four miles south of the river, where for a long distance there is almost an unbroken line of cliffs varying from 100

to 500 feet in height. Some of these bluffs are vertical, and, in some cases, overhanging. They are composed of regular horizontal strata of beach-sand, gravel, and boulders. Beneath these are the trunks of very large redwood trees, lying horizontally, and stumps standing in their natural position, but below the present ocean level, showing a change of level both in the land and sea. At low water there is a narrow beach, but when the tide is full the sea washes the base of the cliffs. The method of working is to wait until the surf strikes the beach at an angle.* When the direction of the wind is such that the surf breaks perpendicularly on the beach, masses of coarse gravel are thrown up, and no black sand, but when the waves strike the beach at an angle, the gravel is washed into heaps in certain places, and in others black sand, more or less rich in gold, is deposited. During heavy weather the beaches cannot be worked, as they are usually too narrow, and the action of the waves prevents the deposition of the black sand. During a severe storm, the whole surface is covered, so that the surf strikes the base of the cliff, and when it subsides the shape of the beach will usually be entirely changed. Generally, the sand containing the gold lies on the top, but sometimes the black sand is covered over with a deposit of barren material, which has first to be scraped away before the black sands can be collected.

At Ophir Beach, near Rogue River, Oregon, the beach below high water is washed in a small way by the sluicing process, when the sand that is thrown up is rich enough to pay. The superintendent examines the beaches every day, collecting the sands and scraping up the loose gravel; he pans it, and on finding a "prospect," sends for a mule train, each mule carrying two coarse hide or canvas bags, which will contain about 125 pounds each; a train of 40 mules would, therefore, transport 10,000 pounds, or five tons at a single trip. In order to collect the sand the top gravel is stripped and the black sand gathered into piles. The canvas sacks are taken from the mules and filled, the mules being trained to start on a run for the works the moment they are loaded. As in some places the sea comes close up to the cliff, the animals are trained to turn their heads toward the cliff, bracing their feet firmly, allowing the wave to dash over them, and then going on their way on a run till the next wave comes. During a single tide, these

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* Mining Com. Rept., 1874, p. 145.

mules, under favorable conditions, are able to make three trips, when the distance to the working place is not too great. At the works the sand is piled up and washed in rockers, long toms, or sluices, with amalgamated plates.

At Randolph, in Oregon, at the mouth of Whiskey Run, the gold in the sands was always very fine. No nuggets of more than four to five cents in value were found, but the sand was very rich. Only a small portion of the gold was saved. Much of the ground was worked over six or seven times in succession, and was each time found to be remunerative. For a very short time a single miner could earn a thousand dollars a day,* but the prosperity was of short duration. The town has been in ruins for many years. The largest amount ever taken out of any of the California beach-claims is said to have been $25,000 in one year. The great difficulty in working the beaches has always been the lack of fresh water. They have been washed with salt water pumped from the sea, but the amount of gold collected in such cases was only a small portion of what was lost.

All the experience of these beach mines goes to show that immediately after a heavy cave or slide on the banks, the beaches are rich in coarse gold, but up to the present time it has not seemed profitable to do any bank-blasting or to undertake mining on a large scale by the hydraulic processes. The gold is washed up by the sea only. Many suggestions have been made that the gold would be found in the sea beyond the surf-line, and some attempts to dredge for it have been made, but unsuccessfully.

It was proposed at one time to effect the amalgamation of these extremely light particles before endeavoring to concentrate them, by heating the sand and quicksilver under water up to the boiling point, which would cause the mercury to diffuse itself through the entire mass, and thus attack the gold that was in a proper condition to amalgamate. If this sand had been previously calcined, the first calcination and the subsequent heating would be sufficient in most cases to remove the coating upon the gold. In some cases a chemical treatment of the sand was made, and after all this was done, the fine particles of amalgam had still to be collected by boiling, and unless they were very rich and fuel plenty, it is evident that such a method as this, although patented and supposed to be

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* Min. Com. Rept., 1873, p. 207.

worth a great deal of money, could not be successful. The process* consisted in screening the sand and subjecting it for twenty-four hours to a solution of caustic potash and salt, for removing any coating upon the gold, and destroying the compounds of sulphur which would attack the mercury. The material so treated is heated in a pan by a jet of steam, and the quicksilver poured in; it was kept constantly in agitation by the steam, and the movement kept up from a quarter to half an hour, by which time the gold should have become thoroughly amalgamated. The pulp was discharged into a vat to cool. It is desirable that it should not be heated too much, as that divides the quicksilver more than is necessary to secure the amalgamation. Care must be taken to use pure quicksilver in the process. The cooled material was then passed over a series of copper rollers grooved spirally and set, the one above the other. These are set over a sluice, three feet wide, with amalgamated copper plates and grooved copper rolls. The rollers are hollow, 1 foot in length, and 2 inches in diameter. As the amalgam accumulates on the rollers, it is either cleaned off or drops into the sluice below. Notwithstanding all that was hoped for it, the process was not successful.

It does not seem likely that beach mining will ever be very remunerative; the uncertainties connected with the value of the sands, and the times when the beaches can be worked, for they will often be unworkable for months together, either because the storms are so high as to denude the beach, or the weather so calm that there is not force enough in the waves to throw up the black sand on the beach or wash it down from the cliff. It is not probable that it will ever justify the investment of a large capital. That it will, however, yield a fair return for a small outlay, is generally true. Persons residing in the vicinity of these beaches have often made a fair living by working them when they could be worked, but no company, whatever its prospect at the commencement, and however rich the beach when they began to work it, has ever been able to work these sands with profit for any considerable length of time. There are places where if fresh water in sufficient quantities could be had, the bluffs might be worked by hydraulic methods, but even this would not be justified if the line of ditch was to be very long, or if the storage of the water required the con-

* Min. Com. Rept., 1875, p. 317.

struction of large dams. The immediate disposal of the tailings by the sea looks at first sight very attractive, but it remains to be seen whether the accumulation of enormous amounts of débris would not stop the encroachments of the sea, and whether in working such fine gold on an enormous scale, sufficient of it could be caught to make the enterprise profitable.

River and Bar Mining.

Bars are the deposits that form in streams which bring down auriferous gravel, when the stream strikes a hard rock, and is deflected to the other side of its course. Parallel to the line of deflection, at an angle more or less great to the course of the stream, bars will form, on and in which the gold lodges. In a modern stream, these bars will, sometimes, rise above the surface, and are worked in a small way. The ancient rivers, however, formed bars upon a much larger scale. Such bars, running across the channels of these ancient streams, most of which have disappeared ages ago, can be worked with great profit by hydraulic methods. They are found where the river still retains its ancient course, but the diminished size of the modern stream will frequently make these bars from 40 to 50 feet above the present high-water level. They are ordinarily worked by the hydraulic methods. Where the bars are simply in the rivers of the present time they are of local and transient interest only, as they are very soon worked out. The gold they contain has sometimes been so concentrated by the action of the stream that a single panful has been known to yield more than $100. They have been pumped and dredged, but they do not generally justify any large expenditure, and all workings based on any large yield for a period of time have been unsuccessful. Such plans were proposed at Oroville on Feather River, California, but the failure was as great and disastrous as the expectations were large and promising. The Chinese are, however, working these deposits and make a fair living out of these abandoned bars or their tails.

In very many rivers in California and elsewhere which run through alluvial deposits containing gold, or which have abraded the outcrops of veins containing it, there is a deposit more or less large of gold in their beds. In this case, which is very common in California, two methods are used. One is to dredge, or pump the sand from the river bed or to undermine it, and another is to

remove the whole of the water from the river by means of a flume and "flutter wheels," and then to work the ground of the river bed and beneath it. Such experiments as these are extremely hazardous, as the least defect in the construction of a flume or a freshet may break up the whole of the works, the outlay for which must of necessity be very large. They can, therefore, only be undertaken during the summer, when the water is low and when there is no danger of sudden rises in the river. Flumes commenced before the spring rains were over have more than once been carried away before they were finished. Usually these river claims, as they are called, are kept dry from leaks in the dams and from the water of small streams which enter the sides by wheels which work in the flumes constructed to carry off the water by the force of the current.

On Feather River,* in Butte County, California, on the "Cape claims," two wing dams were constructed across the river. All the water above the first dam was carried by a large flume to the lower one. The water between the two dams was pumped out by wheels run by the current in the flume. The gravel on the river bed was washed in sluices, and during forty-two days yielded $680,000. Only one-third of the ground had then been washed out when the flume was destroyed. Such methods can only be employed on small streams in the dry season when there is the least water to contend with. The stream must be diverted from its course or pumped out. Such methods, as shown by the example cited above, are full of risk. They seem very attractive when the rich pay dirt is brought up from the bottom and the calculation is made of how much gold is contained in the river bed, but it is seldom worth while to flume them for a short distance,—generally it will not pay to do it for less than three or four hundred feet, and often more must be flumed,—and when all the water has been pumped out, derricks run by hurdy gurdy wheels or by hand power must be erected to remove the large rocks to get at the gold beneath them, with no certainty that the whole of the work will not be swept away by a sudden rise in the river.

When such a method is not practicable, the river is explored to find the bars and rich placers. When they are located, a shaft is sunk to the depth of 40 to 60 feet above high water-level, and a

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* Prod. Gold and Silver in U. S., 1880, p. 328.

drift run in the rock under the bars. The gravel is taken out from above, hoisted to the surface, and washed in sluices. The water pumped from the shaft, can, if necessary, be stored for washing. Gravel containing only seventy cents a cubic yard is worked in this way.

Where the quantity of water is, or is likely to be, small, in order to economize it, it is the custom to dam the stream, and, when the water has accumulated sufficiently, to open the gates and allow it to rush out against the gravel with great force. This process, called "booming," is sometimes carried on by hand power and sometimes automatically. When the process of "booming" is carried on automatically, it is effected with the use of the so-called "shot-gun dam." This is an automatic discharge gate, so constructed as to have the gate of the dam lifted at intervals by the water itself; to do this the gate is attached to one end of a suspended beam, which has a water-tight box with a valve in the bottom, attached to the other. When the dam is full a part of the water flowing over passes into a launder, arranged for the purpose, which conducts the water to the box. This is so adjusted that when it is full it lifts the gate by itself sinking. The contents of the reservoir is thus instantly released, and flows with great force and rapidity to the point where it is to be used. After it has fallen a certain distance the valve of the water box comes in contact with an upright post, which opens it and lets the water out. The empty box rises and closes the gate. This is repeated at regular intervals, giving a heavy head of water and a rapid current every few minutes. This method has been extensively used both in Colorado and California. Before this method was invented the gate was always lifted by hand and required the constant attendance and care of one man. By the present method the gate requires to be looked after only occasionally. The work is entirely automatic, the number of times per hour that the gate is lifted being perfectly regular and depending only on the supply of the water.

It has been proposed, and a great many attempts have been made, to raise the gold contained in the river gravels from the bottom of the streams with powerful pumping engines, capable of raising 25,000 cubic meters in the course of twenty-four hours, half of the bulk being water. It is claimed that these pumps are cheaper and better than any dredging machines. Notwithstanding these assertions, however, neither dredging nor pumping has proved

successful, for the reason that the river can only separate the gold in the same way that a sluice does. The idea of most persons not familiar with river sands, is that the sand is deposited in regular stratified layers, and that the gold is disseminated regularly through them. No one who has any experience in sluice mining would believe this, for the whole object of the sluice is to provide places where the gold may be caught in mercury, the bottom of the sluice being arranged with reference to this. At the bottom of the river the sands are always unequally distributed. The bed rock is never even, but is always filled with crevices, into which the gold falls by gravity and is not accessible to the dredge. Where the river flows over a soft gravel, and the bed rock is either turned on its edge or is soft from decay, it is well known to gravel miners that the gold will penetrate the bed rock sometimes for a considerable distance, so that it is frequently worth while to take it up for some depth. Dredging and pumping machinery must do their work progressively and systematically, starting from a fixed point and proceeding toward some other. It is impossible for the machine to find where the gold lies, and even if every spot were known beforehand, the irregular nature of the deposit, and the fact that the bed rock is often the richest part of it, would make it impossible to work a spot here and there, so that in pumping or dredging the barren material will be more likely to be raised, even supposing the gold is actually there, than that which contains it, as the gold is hidden away in pockets beneath the ground, which can be reached by the dredge. These processes, therefore, have not been successful, and it may be stated as a general proposition that if the river bed is poor it will not pay to work it by any method, and if it is rich the usual process of damming and fluming, which has sometimes proved successful, with all its uncertainties, is probably the best, as it is certainly the cheapest method of working it in dry seasons when the flumes are properly constructed. In such a case the practiced eye of the miner distinguishes the points where the gold is likely to be found and works those points only, leaving the barren material behind, but the machine must take poor and rich as it comes, and cannot in any case work the bed rock.

It would be impossible to state any yield for the placer deposits as an average. Those which have been published were interesting at the time because they were extraordinarily large, while the poor yields have not been made known. The few successes have been

heralded all over the world, but the great army of unfortunate ones has not been heard from, and scarcely excites any commiseration or sympathy. To average the few successes of the fortunate with the immense number of failures would bring the gains down so very low that few thinking men, if they were to consider the proposition by itself, would care to run the risks of placer mining, but every one hopes that he will be one of the fortunate ones, and hence many make the attempt. It is doubtful whether, over a large and moderately rich district averaging successes and failures, the yield is as much as ten dollars a day for each man, and this, with the great cost of living in the places and times when such mining is possible, is scarcely more than a bare living. How many men never found enough to keep their hearts up, and died, either in the field or the insane asylum, from grief over the loss of all they had saved, or from disappointment at never having realized their dreams of wealth, we shall never know, but the number must have been very large to bring the average down so low. James Marshall's life and death are an excellent illustration of the proverb: "He that hasteth to be rich hath an evil eye, and considereth not that poverty shall come upon him."*

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* Proverbs, xxviii., 22.